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Character Association Studies for Yield and Lodging related Parameters in Rice (*Oryza sativa* L.)

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ABSTRACT

Studies on character association for yield and lodging parameters were conducted on 24 different Near Isogenic Lines of rice along with their respective parents developed for submergence, lodging and salinity tolerance by using marker assisted backcrossing. Analysis of variance revealed considerable variability among the entries for all the characters studied. Correlation analysis revealed that grain yield per plant has significant positive genotypic association with number of grains per panicle, days to 50% flowering and panicle length and negative association with 1000 grain weight, basal internodal length and per cent of lodging. Indirect selection for these traits inherited together positively would be rewarding for the development of high yield varieties. Per cent of lodging showed highly significant negative association with culm diameter, culm thickness and bending stress of lodging related traits indicating that careful selection for wider, thicker culms coupled with high yield would result in non lodging varieties.

Key words: *Grain yield, lodging, near isogenic lines, salinity, submergence*.

Rice is prone to lodging in coastal areas due to unpredicted cyclonic rain at reproductive phase. Lodging of the crop results in drastic yield reduction. This usually occurs only after the ear or panicle has emerged and results in the shoots permanently leaning or lying horizontally on the ground. Lodging of the rice crop in coastal areas not only reduces yields but also causes deterioration in quality, *in situ* germination, increases drying and harvesting costs which also impedes mechanical harvesting.

Lodging can cause severe yield loss and poor grain quality because of reduced canopy photosynthesis, increased respiration, reduced translocation of nutrients and carbon for grain filling and increased susceptibility to pests (Hitaka, 1969). Many studies have shown that the culm characteristics contributing to lodging resistance include basal internode length and thickness, plant height, culm wall thickness, and leaf sheath wrapping and thickness. Lodging often contributes to uneven maturity, high moisture content and loss of grain quality due to sprouting and possible moulding. Setter *et al*. (1997) showed that 1% reduction in grain yield occurred for every 2% lodging.

Many researchers have reported relations between the lodging and other traits (Islam *et al*., 2007; Ookawa and Ishihara, 1993). Lodging resistance in rice depends on many traits that affect directly or indirectly the culm strength. Culm strength deterioration from grain filling to the fully ripe stage is one of the main causes of rice lodging. Culm strength is associated with morphological, anatomical traits of the stem and also with several biochemical traits. Hence careful selection for those positive effect traits will help to improve the targetted trait. Research results established by many groups showed that plant height, culm diameter and thickness were the major traits determining lodging resistance. Kashiwagi and Ishimaru (2004) to understand culm strength of rice crop, they measured the pushing resistances (physical strength) of the lower part and the whole plant of rice at the fully ripe stage with a prostrate tester. To identify non-lodging lines with sufficient culm strength simultaneous selection for higher pulling force and recovery angle after bending, along with higher culm diameter and plant height appears to be relevant. Lodging primarily occurred at the lower internodes including the third and fourth

internodes from the tops of the plants (Hoshikawa and Wang, 1990). The stiffness of the basal stems (the culms and leaf sheaths) was positively correlated with the lodging resistance. A higher dry weight per cm of culm, culm diameter and wall thickness were all helpful in increasing the bending strength (Islam *et al*., 2007).

Yield is a complex character influence by adverse weather parameters. Selection of high yielding lodging resistance genotypes is a major challenge in the present scenario of climate changed conditions.

Understanding the relationship between yield and lodging related traits is of paramount importance for making the best use of these relationships in selection of non lodging high yielding genotypes. The present study was, therefore, undertaken to understand the character association for yield and lodging related parameters among 24 entries of rice.

MATERIAL AND METHODS

Experimental material consisting of 24 rice Near Isogenic Lines (NILs) along with their corresponding recipient and donar parents developed for submergence, lodging and salinity tolerance were collected from APRRI & RARS, Maruteru, West Godavari District. The material was grown in a Complete Randomized Block Design with two replications during *Kharif* 2016. Observations were recorded on five randomly selected plants of each line per replication for 14 traits *viz.,* plant height, ear bearing tillers per plant, days to 50 % flowering, number of grains per panicle, spikelet fertility, 1000 grain weight, panicle length, grain yield per plant, culm diameter, culm thickness, basal internodal length, per cent of lodging, culm strength, bending stress.

Culm diameter and thickness was measured at 4th inter node from the top at 20 days after heading using vernier calipers and expressed in millimeters (mm). Basal internodal length between 4 and 5 nodes from the top was measured and expressed in cm. Culm strength at the maturity stage was rated based on the inclination of the tillers as per the SES of IRRI, 2013 by pushing hill forward and back for few times at maturity.

Scale (plants lodged)

1 Strong (no bending)

3 Moderately strong (most plants bending)

5 Intermediate (Most plants moderately bending)

7 Weak (most plants nearly flat)

9 very weak (all plants are flat)

It was measured by pushing hill at 20 cm above the ground at 45^0 angle using Prostrate tester and it was expressed in g/stem using the following formula as per Bhagat *et al*. (2011).

Bending strength= [(Test reading/40) X (1000/ number of tillers)]

Lodging incidence was determined as per cent ratio of plants lodged as per IRRI, 2013 standard evaluation system (SES) under natural conditions at maturity stage.

Genotypic and phenotypic correlation coefficients for all the possible comparisons were computed as per the formulae suggested by Falconer (1964).

RESULTS AND DISCUSSION

Grain yield per plant showed significant positive genotypic association with number of grains per panicle, days to 50 % flowering and panicle length and negative significant association with 1000 grain weight, per cent of lodging and basal internodal length. Selection for long duration genotypes with long panicle and more number of grains per panicle would help in realization of higher yield by virtue of its positive genotypic association with number of grains per panicle, days to 50 % flowering and panicle length. Indirect selection inherited together would be rewarding for yield enhancement. These results were in similarity with Sudharani *et al.*(2013), Seesang *et.al.*(2013), Bagati *et al*. (2016), Ashok *et al*. (2016) for number of grains per panicle, Hasan *et al.* (2011), Aditya and Bhartiya (2013), Khare *et al*. (2014) for days to 50% flowering, Yadav *et al.* (2010), Akhtar *et al*. (2011) for panicle length.

Per cent of lodging showed significant and positive association with 1000 grain weight, culm strength, ear bearing tillers per plant and negative significant association with plant height, days to 50 % flowering, number of grains per panicle, spikelet fertility percentage, panicle length and grain yield per plant, culm diameter, culm thickness, bending stress. The above results showed that lodging tendency of genotypes associated with more no. of ear bearing tillers, higher 1000 grain weight and higher value of culm strength. Selection for non lodging genotypes results in dwarf plants, with more number of grains per panicle and spikelet fertility % indicating that lodging tendency of genotypes decreases yield by virtue of its negative association with yield parameters. These results were in

accordance with Li *et al*. (2011), Yang *et al*. (2012), Jiang *et al.* (2014), Laza *et al*. (2014), and Zhang *et al.* (2016).

Plant height showed positive significant association with spikelet fertility, panicle length, number of grains per panicle, culm diameter, culm thickness, basal internodal length, and bending stress and significant negative association with 1000 grain weight, per cent of lodging and culm strength. Selection for wider and thicker culm with moderate plant height (120-130 cm) results in realization of non lodging plants with higher yield this was reflected in terms of negative association of per cent of lodging and culm strength. Ear bearing tillers per plant showed significant positive association with 1000 grain weight, per cent of lodging and significant negative association with days to 50 % flowering, number of grains per panicle, culm thickness, bending stress. These results indicated that selection for more number of ear bearing tillers per plant leads to decrease in number of grains per panicle, bending stress which indirectly results increase in test weight and weakens the culm strength. These are in conformation with earlier reports of Sravan *et al.,* (2012), Ashok *et al*., (2016), Chandrasekhar and shailaja (2017).

Days to 50 % flowering showed positive and significant association with no. of grains per panicle, grain yield per plant, culm diameter and culm thickness, bending stress and negative significant association with 1000 grain weight, per cent of lodging, culm strength and results revealed that long duration genotypes would produce more number of grains per panicle possessing wider, thicker and strong culm traits which are desirable for development of non lodging genotypes. This can be attributed as earlier duration genotypes would give few numbers of tillers per plant, lower test weight, minimum lodging tendency and lower culm strength values. Number of grains per panicle showed positive significant association with panicle length, grain yield per plant, culm diameter, culm thickness, bending stress and negative association with 1000 grain weight, per cent of lodging, culm strength. These results indicated selection for genotypes with more no. of grains per panicle would give high yield with wider and thicker culm but this type of genotypes would give few no. of ear bearing tillers with less test weight with non lodging tendency. These are in conformation with earlier reports of Santhi *et al.* (2017), Bagati *et al*. (2016) and Ashok *et al*. (2016)

Spikelet fertility % showed significant and positive association with culm diameter, culm thickness and bending stress and it showed negative and significant association with per cent of lodging and culm strength. These results indicated that non lodging genotypes expresses more spikelet fertility % as it is positively associated with culm diameter, cum thickness, bending stress and negative asoociated with per cent of lodging and culm strength. 1000 grain weight showed positive and significant association with per cent of lodging, culm strength it showed negative and significant association with culm thickness, culm diameter, grain yield per plant and bending stress. Thus genotypes with more test weight of heavy panicles would prone to lodging. These are in conformation with earlier reports of Chandrasekhar and shailaja (2017) and Sravan *et al.* (2012)

Panicle length showed positive significant association with basal internodal length, grain yield per plant and negative association with per cent of lodging. Genotypes with larger panicles would give higher yield with strong culm explained by its significant positive association with grain yield per plant and basal internodal length. Indirect selection of this trait would results in high yielding genotypes. Culm diameter showed positive significant association with culm thickness and bending stress and possessed significantly negative association with per cent of lodging and culm strength. Selection for genotypes with wider culm results by positive association with yield parameters (plant height, days to 50 % flowering, number of grains per panicle, spikelet fertility %) and lodging related trait *viz.*, culm diameter and bending stress exhibited significant negative association with per cent of lodging and culm strength in a desirable direction. These are in conformation with earlier reports of Bagati *et al.* (2016), Zhang *et al.* (2016)

Culm thickness showed positive and significant association with bending stress and significant negative association with per cent of lodging and culm strength indicate that genotypes with more culm thickness will minimize lodging and culm strength score ultimately results in evolving non lodging genotypes. Basal internodal length showed negative significant association with culm strength indicates that with genotypes with short basal internodal length would lead to decrease in grain yield per plant. Hence, careful selection has to be exercised in selection of non lodging genotypes with short basal internodal length. Increase in basal

Table 1. Estimates of phenotypic and genotypic correlation coefficients among yield and lodging related traits in rice

Characters		plant height (cm)	ear bearing tillers per plant	Days to 50% flowering	Number of grains per panicle	Spikelet fertility %	1000 grain weight	panicle length (cm)	Grain yield per plant (g)	Culm diameter (mm)	Culm thickness (mm)	Basal internodal length (cm)	Per cent of loading (%)	Culm strength	Bending stress (g/stem)
Plant height (cm)	P	1.000	-0.025	0.080	0.280	0.356*	-0.267	0.342*	-0.027	0.573**	0.459**	0.409**	-0.457**	-0.458**	0.247
	G	1.000	-0.099	0.087	0.345*	0.423**	-0.299*	0.416**	0.069	0.634**	0.542**	0.442**	-0.498**	-0.528**	0.333*
Ear bearing tillers	P		1.000	-0.690**	-0.494**	0.092	0.555**	0.136	-0.152	-0.001	-0.298*	-0.056	0.257	0.054	-0.574**
per plant	G		1.000	-0.923**	-0.674**	0.202	0.717**	0.043	-0.221	-0.082	-0.437**	-0.094	0.359*	0.133	-0.559**
Days to 50% flowering	P			1.000	0.594**	0.150	-0.799**	-0.188	0.284	0.321*	0.460**	0.079	-0.420**	-0.379**	0.482**
	G			1.000	0.614**	0.166	-0.805**	-0.237	0.293*	0.333*	0.495**	0.079	-0.423**	-0.392**	0.539**
Number of grains	P				1.000	0.264	-0.707**	0.239	0.580**	0.436**	0.385**	-0.123	-0.661**	-0.351*	0.408**
per panicle	G				1.000	0.267	-0.726**	0.294*	0.629**	0.481**	0.448**	-0.131	-0.678**	-0.409**	0.481**
Spikelet fertility%	P					1.000	-0.230	0.151	0.133	0.623**	0.393**	0.173	-0.662**	-0.667**	0.432**
	G					1.000	-0.257	0.159	0.165	0.716**	0.478**	0.195	-0.721**	-0.771**	0.471**
1000 grain weight(g)	P						1.000	0.054	-0.450**	-0.376**	-0.321*	0.044	0.425**	0.348*	-0.326*
	G						1.000	0.079	-0.473**	-0.394**	-0.371**	0.048	0.428**	0.359*	-0.350*
Panicle length (cm)	P							1.000	0.200	0.213	-0.160	0.214	-0.242	-0.165	-0.034
	G							1.000	0.393**	0.222	-0.094	0.305*	-0.300*	-0.182	-0.004
Grain yield per	P								1.000	0.151	-0.099	-0.332*	-0.282	-0.247	0.014
plant (g)	G								1.000	0.136	-0.116	-0.348*	-0.306*	-0.261	0.020
Culm diameter (mm)	P									1.000	0.650**	0.184	-0.746**	-0.851**	0.569**
	G									1.000	0.797**	0.230	-0.776**	-0.884**	0.660**
Culm thickness (mm)	P										1.000	0.129	-0.727**	-0.592**	0.618**
	G										1.000	0.117	-0.810**	-0.698**	0.822**
Basal internodal	P											1.000	-0.127	-0.277	0.227
length (cm)	G											1.000	-0.132	-0.319*	0.269
Per cent of lodging (%)	P												1.000	0.787**	-0.696**
	G												1.000	0.825**	-0.769**
Culm strength	P													1.000	-0.635**
	G													1.000	-0.713**
Bending stress	P														1.000
(g/stem)	G														1.000

internodal length leads to lodging of the crop. These are in conformation with earlier reports of Yang *et al.* (2012), Jiang *et al.* (2014) and Zhang *et al.* (2014).

Conclusion

Present study revealed that indirect selection for wider, thicker culms, intermediate height of 125-130 cm would results in non lodging genotypes with higher yield. Strong culm varieties would give higher yield owning to their larger panicles and more number of grains.

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